installation,
operation,
and maintenance
instructions

Manual No. 6999-05-564

Revision A

varian

vacuum

products

564 IONIZATION GAUGE

varian/vacuum products/121 hartwell avenue/lexington/massachusetts 02173/ (617) 861-7200

DESCRIPTION

Varian's 564[1] Ionization Gauge Tube is a broad-range, Bayard-Alpert type vacuum gauge tube. It is designed for measuring vacuum in a wide range of pressures. Careful adherence to manufacturing techniques and standards insures close agreement between gauges. Initial calibration against closely checked McLeod gauge standards insures that this calibration is as well-founded as present state of the art will permit[2].

Unique with its high-pressure capability and low X-ray limit, the 564 tube is usable to 1×10^{-1} Torr in argon and 6×10^{-2} Torr in air. This is accomplished by the smaller geometry of the tube elements and the use of a conductive platinum coating on the inside of the glass envelope which improves gauge tube performance.

In the high and ultra-high vacuum range, the platinum shield prevents external electrical fields from affecting the low ion current. In the higher pressure ranges where the number of ions produced is much greater, the platinum conductive coating drains off the static charge which can build up on the inside of the glass tube. The 564 tube thus gives superior performance throughout the entire range of the tube.

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1 US Patent 3,839,655

2 See: "A Detailed Examination of the Principles of Ion Gauge Calibration", W.B. Nottingham and F. L. Torney, Jr., Vacuum Symposium Transactions, 1960, p.117.

SAFETY CONSIDERATIONS

READ THE FOLLOWING INSTRUCTIONS;
TAKE ALL NECESSARY PRECAUTIONS

HAZARDS

The following format is used in this manual to call attention to hazards.

WARNING
WARNINGS ARE USED WHEN FAILURE TO OBSERVE INSTRUCTIONS OR PRECAUTIONS COULD RESULT IN SERIOUS INJURY OR DEATH.

CAUTION
CAUTIONS ARE USED WHEN FAILURE TO OBSERVE INSTRUCTIONS COULD RESULT IN DAMAGE TO EQUIPMENT, WHETHER VARIAN-SUPPLIED OR OTHER ASSOCIATED EQUIPMENT.

Note
Information to aid the operator in obtaining the best performance from the equipment.

Operators and service personnel must be aware of all hazards associated with this equipment. They must know how to recognize hazardous and potentially hazardous conditions, and know how to avoid them. The consequences of unskilled, improper, or careless operation of the equipment can be serious. This product must only be operated and maintained by trained personnel. Every operator or service person must read and thoroughly understand operation/maintenance manuals and any additional information provided by Varian Associates. All warnings and cautions should be read carefully and strictly observed. Consult local, state, and national agencies regarding specific requirements and regulations. Address any safety, operation, and/or maintenance questions to your nearest Varian office.

SAFETY CONSIDERATIONS

READ THE FOLLOWING INSTRUCTIONS;
TAKE ALL NECESSARY PRECAUTIONS

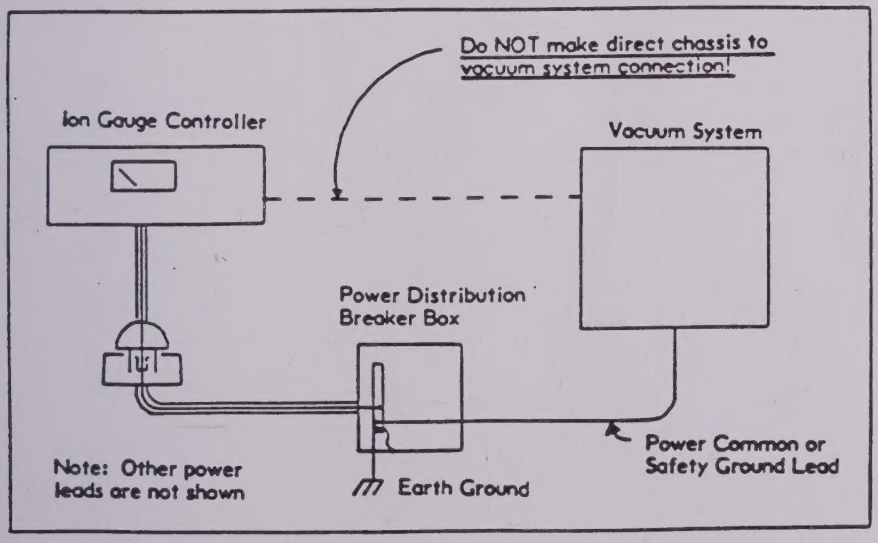
⚠WARNING

Check that your Ion Gauge Controller and vacuum system are SEPARATELY grounded to a common ground.

Placement of a ground wire between the vacuum chamber and the controller chassis is NOT SAFE; large continuous currents could flow through it.

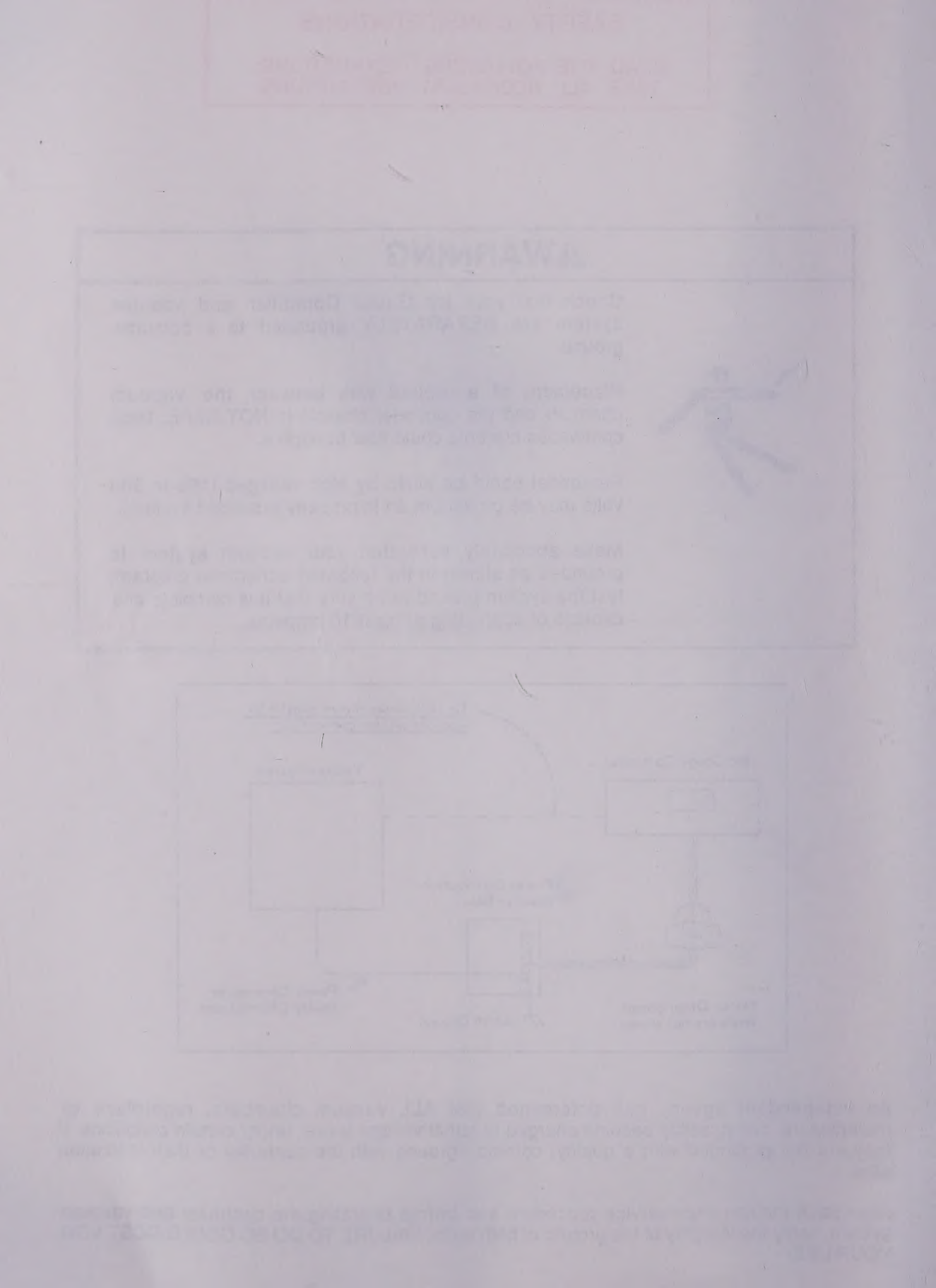
Personnel could be killed by high voltages (160 to 900 volts may be present in an improperly grounded system).

Make absolutely sure that your vacuum system is grounded as shown in the following schematic diagram; test the system ground to be sure that it is complete and capable of supporting at least 10 amperes.


Do NOT make direct chassis to vacuum system connection!
Ion Gauge Controller
Vacuum System
Power Distribution Breaker Box
Power Common or Safety Ground Lead
Note: Other power leads are not shown
Earth Ground

An independent agency has determined that ALL vacuum chambers, regardless of manufacture, can possibly become charged to lethal voltage levels, under certain conditions, if they are not grounded with a quality, common ground with the controller of their ionization tube.

After each maintenance/service procedure and before operating the controller and vacuum system, verify the integrity of the ground of both units; FAILURE TO DO SO COULD COST YOU YOUR LIFE!



SAFETY CONSIDERATIONS

READ THE FOLLOWING INSTRUCTIONS;
TAKE ALL NECESSARY PRECAUTIONS

⚠WARNING

This equipment contains high voltages (up to 3000 volts), high enough to produce electric shock and cause death or serious injury.
Equipment utilizing these controls should be designed to prevent personal contact with high voltages.
Always break the primary circuit when direct access to the control unit is required.

OPERATION

WARNING
BECAUSE THE FILAMENT OF A HOT FILAMENT ION GAUGE AND THE HIGH VOLTAGE DISCHARGE OF A COLD CATHODE GAUGE CAN BE IGNITION SOURCES, EXTREME CARE SHOULD BE EXERCISED WHEN USING A VACUUM GAUGE WHILE PUMPING OR BACKFILLING A SYSTEM OR ANY OTHER SYSTEM CONDITION WHICH CONTAINS COMBUSTIBLE GASES OR MIXTURES. WHEN SUCH A GAS OR MIXTURE IS PRESENT, DO NOT TURN ON ANY SUCH VACUUM GAUGE. FAILURE TO FOLLOW THIS INSTRUCTION COULD RESULT IN SERIOUS INJURY TO PERSONNEL AND/OR DAMAGE TO EQUIPMENT.

The Varian 564 Ionization Gauge Tube can be used with a variety of commercial controls which are equipped for resistance degassing. **It is particularly important to note whether a control will exceed any of the maximum ratings noted in this instruction manual.** For this reason, it is recommended that this gauge tube be operated with an Ionization Gauge Control which has been specifically designed for it and thus can take advantage of its broad range.

The thoria-coated iridium filament resists burnout from accidental exposure to atmosphere. When used in argon atmosphere, the tube can operate continuously at 1×10^{-1} Torr with no effect on filament life. Tube life in air may be shortened above 1×10^{-3} Torr.

SENSITIVITY

The sensitivity of an ionization gauge tube is defined as the ion current per unit of pressure at a specified grid (electron) current. Since all ionization gauge tubes are sensitive to the type and pressure of a gas, the gas composition must be known to correctly establish the pressure reading.

$$S = \frac{i^+}{i^-} \cdot \frac{1}{p}$$

where: S = the sensitivity (in $Torr^{-1}$)
i^+ = the ion current (in amperes)
i^- = the grid (electron) current (in amperes)
p = the partial pressure of the gas (in Torr)

GAUGE TUBE SPECIFICATIONS

Range:	1×10^{-1} to 4×10^{-10} Torr
Sensitivity (air):	8 per Torr
Maximum Operating Pressure:	1×10^{-1} Torr (argon); 6×10^{-2} Torr (air)
Pumping Speed (ionic):	0.06 liters/sec (Nitrogen) (1mA)
X-Ray Limit:	Approximately 4×10^{-10} Torr (Nitrogen)
Initial Calibration:	McLeod Standard[3]

OPERATING CHARACTERISTICS

Collector:	0 Volts dc (ground)[4]
Shield:	0 Volts dc
Grid:	+180 Volts dc to ground
Filament Bias Voltage:	+30 Volts dc to ground
Filament Voltage:	4.0 Volts ac nominal
Filament Current:	Approximately 3.5 amperes ac (1mA grid current)
Absolute Max. Filament Temperature:	1400°C
Absolute Max. Grid Current:	100 mA

DEGASSING RATINGS

Resistance Heating (Maximum Ratings)

Grid Voltage: 6.3 VAC
Grid Current: 8.7 amperes AC
Grid Temperature: 1200°C

Electron Bombardment (Absolute Maximum Ratings)

Grid to Filament Voltage: +700 VDC
100 mA DC
1200°C Max.
Filament Temperature: 1400°C Max.

If these values are exceeded, sagging of the grid may occur.

OPERATION AND USE

GENERAL

This gauge is designed specifically to be as rugged and reliable as the state of the art will permit. It is important for the user, however, to understand the limitations of any ionization gauge for the longest service and most meaningful results.

MOUNTING

The 564 gauge is designed to mount either in a vertical or horizontal position and may be operated and degassed in either position for prolonged periods without failure.

Any ionization gauge using a hot filament can show pronounced pumping (gauge pressure lower than system pressure) if the conductance of the pipe connecting it to the system is too

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3 Calibration of production standards only.

4 Collector operated at ground potential through electrometer circuit to reduce noise pickup and leakage currents.

low. In general, the gauge tube should be mounted as close as possible to the desired location through a large tubulation (1 inch OD recommended). This effect becomes of particular concern when pressures below 10^{-8} Torr are to be measured.

USE OF THE GAUGE

The 564 gauge may be used to measure equivalent pressure of gases from 10^{-1} Torr down to the X-ray limit of the gauge. All ionization gauges are composition-sensitive and pressure readings derived from these gauges can only be expressed in terms of equivalent pressure of one gas (usually nitrogen).

Because Bayard-Alpert gauge tubes contain hot filaments, outgassing of residual gases in the metal parts of the tube will occur from the time it is first turned on. **It is, therefore, very important to keep the tube as free from contaminating vapors as possible** (diffusion pump fluids, mercury and water vapor, etc.). High-temperature baking of the tube should not be attempted at pressures above 10^{-5} Torr to avoid oxidation of the tube elements which can make it very difficult to attain ultra-high vacuum pressure readings. Conversely, ionization gauge tubes cannot be expected to reach low ultimate pressures if the tube is not thoroughly degassed.

DEGASSING

Degassing of the metal parts and glass walls of the gauge tube may be accomplished by either direct resistance heating of the grid or by electron bombardment of the grid by electrons supplied from the filament of the tube. In either case, it is important to use the values of grid voltage and current recommended to prevent damage to the tube (see Operating Characteristics). In general, electron bombardment will result in a faster cleanup of a Bayard-Alpert gauge tube, but it must be carefully employed and watched to be efficient and non-hazardous to the tube. Prolonged degassing at pressures above 10^{-7} Torr is usually unnecessary and of little value, since the time to readsorb common gases at this pressure is very short.

WARNING
If electron bombardment degassing is employed, high voltages (up to 700 VDC maximum) will be applied to the grid connections; such high voltages can kill. Observe all appropriate precautions.

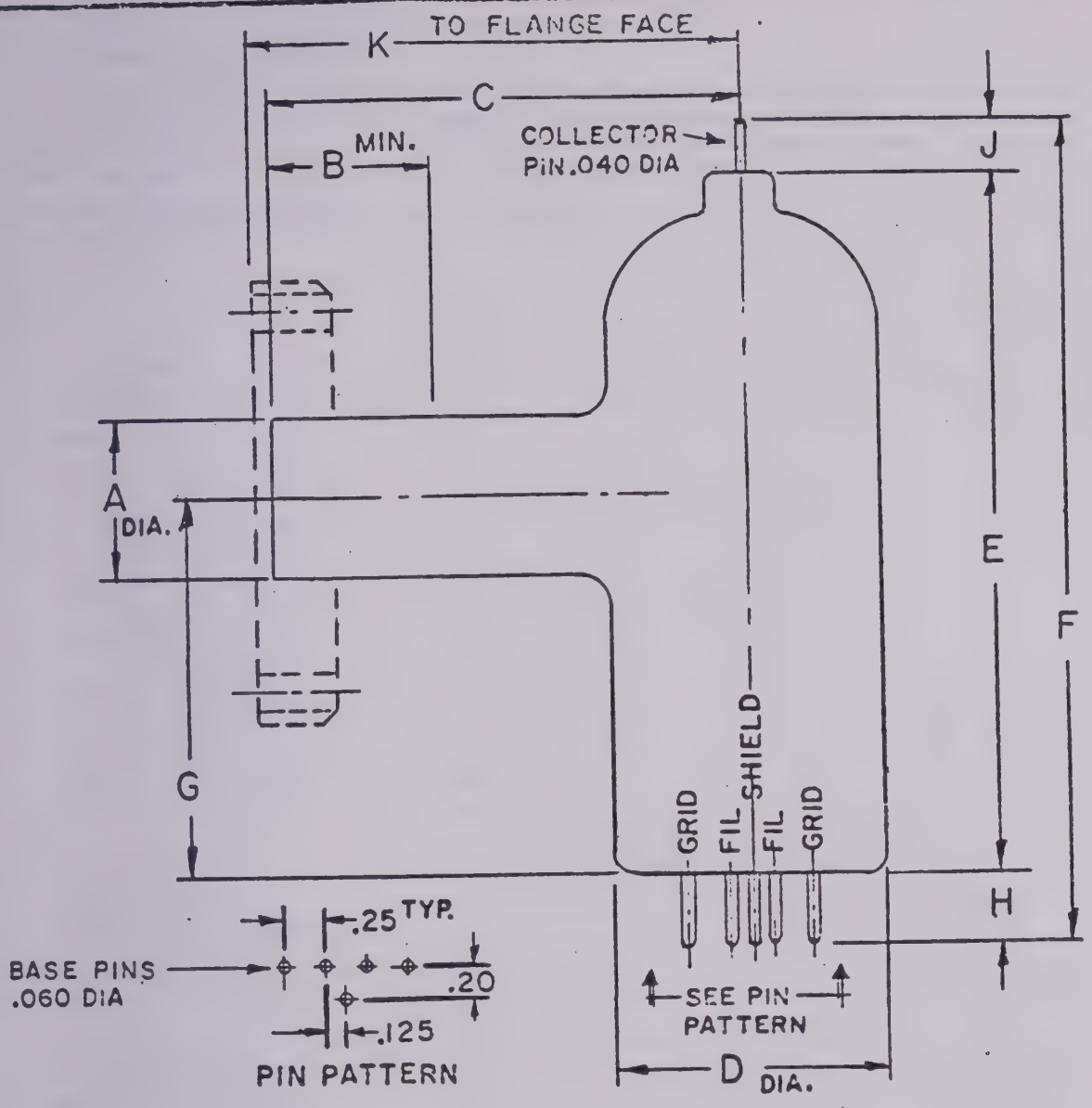
Degassing the gauge tube by resistance heating will typically require one-half hour or more in the high vacuum range, depending on cleanliness of the vacuum system and its past history. Degassing should proceed until the pressure (during degas) has reached a peak, then dropped asymptotically to a lower equilibrium pressure. Allowing the tube to degas overnight will usually ensure this if pressures below 10^{-8} are to be measured.

X-RAY LIMIT

In ionization gauge tubes, X-rays generated by the ionizing electrons hitting the grid produce a

photoelectric emission at the ion collector. This causes a lower limit of pressure readings known as the X-ray limit (about 4×10^{-10} Torr in the Varian Type 564 Gauge Tube). Outgassing effects of the tubes are often mistaken for the X-ray limit. Only careful investigation can determine which is the real cause. A second assumption is often made that the X-ray limit is always constant. This limit depends on (among other things) the photoelectric efficiency of the collector surface which, in turn, depends on the amount of absorbed gas, etc.

Therefore, as the typical value of X-ray limit is approached (4×10^{-10} Torr nitrogen equivalent), readings should not be considered unequivocal.



— 564 IONIZATION GAUGE —

PART NUMBER	A	B	C	D	E	F	G	H	J	K
0564-K2500-301 1" NONEX	1.000 ±.02	1.00 MIN.	2.94 ±.12	1.55 ±.12	4.36 ±.12	5.12 ±.25	2.33 ±.12	.44 ±.06	.31 ±.06	
0564-K2500-302 1" KOVAR	1.000 ±.002	↓	↓	↓	↓	↓	↓	↓	↓	
0564-K2500-303 2 3/4" CONFLAT FLGE	FLGE MODEL	↓	↓	↓	↓	↓	↓	↓	↓	3.00 ±.12
0564-K2500-304 3/4" NONEX	.750 ±.015	↓	↓	↓	↓	↓	↓	↓	↓	

NOTE: ALL DIMENSIONS ARE IN INCHES.

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GAS SENSITIVITY TABLES

The following table lists relative gauge sensitivities for various gases. The values are derived by empirical methods substantiated by measurements reported in literature. The multiple values found in the table represent several different references. This table has been compiled and published by Robert L. Summers of Lewis Research Center, NASA Technical Note TN D-5285, National Aeronautics and Space Administration, Washington, D.C., June 1969.

To convert readings from the ionization gauge control (normally calibrated for nitrogen) divide the indicated pressure by the number listed in the third column for the particular gas (S/S_{n_2}).

Substance	Formula	Relative Ionization Gage Sensitivity, S/S_{N_2}
Acetaldehyde	C_2H_4O	2.6
Acetone	$(CH_3)_2CO$	3.6
		4.0
		3.6
Acetylene	C_2H_2	1.9
		2.0
Air		1.0
		0.98
Ammonia	NH_3	1.3
		1.2
		1.3
Amylene:		
iso-	iso-C_5H_{10}	5.9
cyclo-	cy-C_5H_{10}	5.8
Argon	Ar	1.3
		1.1
		1.2
		0.9
Benzene	C_6H_6	5.9
		5.8
		5.7
		5.9
		6.0
Benzoic acid	C_6H_5COOH	5.5
Bromine	Br	3.8
Bromomethane	CH_3Br	3.7
Butane:		
n-	n-C_4H_{10}	4.9
		4.7
iso-	iso-C_4H_{10}	4.6
		4.9
Cadmium	Cd	2.3
		3.4
Carbon dioxide	CO_2	1.4
		1.4
		1.5
		1.5
		1.4

Substance	Formula	Relative Ionization Gage Sensitivity, S/S_{N_2}
Carbon disulfide	CS_2	5.0
		4.7
		4.8
Carbon monoxide	CO	1.05
		1.05
		1.1
Carbon tetrachloride	CCl_4	6.0
		6.3
Cesium	Cs	4.3
		2.0
		4.8
Chlorine	Cl_2	0.68
		2.6
		1.6
Chlorobenzene	C_6H_5Cl	7.0
Chloroethane	C_2H_5Cl	4.0
Chloroform	$CHCl_3$	4.7
		4.8
		4.8
Chloromethane	CH_3Cl	2.6
		3.2
		3.1
Cyanogen	$(CN)_2$	2.8
		3.6
		2.7
Cyclohexylene	C_6H_{12}	7.9
		6.4
Deuterium	D_2	0.35
		0.38
Dichlorodifloromethane	CCl_2F_2	2.7
		4.1
Dichloromethane	CH_2Cl_2	3.7
Dinitrobenzene:	$C_6H_4(NO_2)_2$	
o-		7.8
m-		7.8
p-		7.6
Ethane	C_2H_6	2.6
		2.8
		2.5
Ethanol	C_2H_5OH	3.6
		2.9
Ethyl acetate	$CH_3COOC_2H_5$	5.0

Substance	Formula	Relative Ionization Gage Sensitivity, S/S_{N_2}
Ethyl ether	$(C_2H_5)_2O$	5.1
		5.1
Ethylene	C_2H_4	2.3
		2.4
		2.2
		2.2 to 2.5
Ethylene oxide	$(CH_2)_2O$	2.5
Helium	He	0.18
		0.15
		0.13
		0.12
Heptane	C_7H_{16}	8.6
Hexadiene		
1,5	1,5-C_6H_{10}	6.4
cyclo-	cy-C_6H_{10}	6.0
Hexane	C_6H_{14}	6.6
Hexene		
1-	1-C_6H_{12}	5.9
cyclo-	cy-C_6H_{10}	6.4
Hydrogen	H_2	0.46
		0.38
		0.41
		0.45
		0.44
Hydrogen bromide	HBr	2.0
Hydrogen chloride	HCl	1.5
		1.6
		2.0
		1.5
Hydrogen cyanide	HCN	1.5
		1.6
Hydrogen floride	HF	1.4
Hydrogen iodide	HI	3.1
Hydrogen sulfide	H_2S	2.2
		2.2
		2.3
		2.1
Iodine	I_2	5.4
Iodomethane	CH_3I	4.2
Isoamyl alcohol	$C_5H_{11}OH$	2.9
Isobutylene	C_4H_8	3.6
Krypton	Kr	1.9
		1.7
		1.7
Lithium	Li	1.9
Mercury	Hg	3.6
Methane	CH_4	1.4
		1.5
		1.6
		1.4 to 1.8
		1.5
		1.5
Methanol	CH_3OH	1.8
		1.9
Methyl acetate	CH_3COOCH_3	4.0
Methyl ether	$(CH_3)_2O$	3.0
		3.0

Substance	Formula	Relative Ionization Gage Sensitivity, S/S_{N_2}
Naphthalene	$C_{10}H_8$	9.7
Neon	Ne	0.30
		0.31
Nitrobenzene	$C_6H_5NO_2$	7.2
Nitrogen	N_2	1.0
Nitrotoluene (o-, m-, p-)	$C_6H_4CH_3NO_2$	8.5
Nitric oxide	NO	1.3
		1.2
		1.0
Nitrous oxide	N_2O	1.5
		1.7
		1.7
		1.3 to 2.1
Oxygen	O_2	1.0
		1.1
		.9
		.9
Pentane:		
n-	n-C_5H_{17}	6.2
		6.0
		5.7
iso-	iso-C_5H_{17}	6.0
neo-	$(CH_3)_4C$	5.7
Phenol	C_6H_5OH	6.2
Phosphine	PH_3	2.6
Potassium	K	3.6
Propane	C_3H_8	4.2
		3.7
		3.7 to 3.9
		3.6
Propene oxide	C_3H_6O	3.9
Propene:		
n-	n-C_3H_6	3.3
		3.2 to 3.7
cyclo-	cy-C_3H_6	3.6
Rubidium	Rb	4.3
Silver perchlorate	$AgClO_4$	3.6
Sodium	Na	3.0
Stannic iodide	SnI_4	6.7
Sulfur dioxide	SO_2	2.1
		2.3
Sulfur hexafloride	SF_6	2.3
		2.8
Toluene	$C_6H_5CH_3$	6.8
Trinitrobenzene	$C_6H_3(NO_2)_3$	9.0
Water	H_2O	1.1
		1.0
		0.8
Xenon	Xe	2.9
		2.2
		2.4
Xylene:		
o-	o-$C_6H_4(CH_3)_2$	7.8
p-	p-$C_6H_4(CH_3)_2$	7.9

varian/vacuum products

TELEPHONE NUMBERS

Order Entry (U.S. only): 1-800-8-VARIAN

(1-800-882-7426)

Fax: (617) 860-5405

From Alaska and Hawaii, dial (617) 861-7200

Service:	U.S.	Tel: 1-800-926-3000 (U.S. only)
	Canada	Tel: 1-800-663-2727 (Canada only) Tel: (905) 819-8188 Fax: (905) 819-8348
	France	Tel: (33) 16-986-3838 Fax: (33) 16-928-2308
	Germany (Darmstadt)	Tel: (49) 61-51-70-32-05 Fax: (49) 61-51-70-32-79
	Germany (Hamburg)	Tel: (49) 40-669-60-33 Fax: (49) 40-668-22-82
	Italy	Tel: (39) 11-997-9111 Fax: (39) 11-997-9350
	Japan	Tel: (81) 3-3588-9732 Fax: (81) 3-3449-4597
	Korea	Tel: (82) 3-333-665-5171 Fax: (82) 3-333-665-0115
	UK	Tel: (44) 932-234-741 Fax: (44) 932-228-769

Training information and registration:

Tel: (U.S. only) 1-800-926-3000; Fax: (713) 240-6752

January 1, 1995

varian

ISO 9001 REGISTERED

HEALTH AND SAFETY CLEARANCE
RETURN AUTHORIZATION POLICY

In compliance with Federal OSHA Safety Standard 1910.1200, Hazard Communications "Right to Know", Varian is enforcing that standard to preclude the potential health risk to its service personnel that can occur when receiving, disassembling, or repairing potentially contaminated products.

Returned products not accompanied by this completed certificate will be held until the completed certificate is received; failure to provide this completed certificate within 30 days of notification will result in the return of held product(s) **UNPROCESSED.**

If a product is received at Varian in a contaminated condition, the customer will be held responsible for all costs incurred to ensure the safe handling of the product.

Company Name: _____

_____ hereby certify that the product(s) listed below have been cleaned of all hazardous residue and that the residue remaining is of a non-hazardous nature.

_____hereby certify that the product(s) listed below have been contaminated by the following toxic or hazardous materials: _____
_____

RA NUMBER	MODEL NUMBER	SERIAL NUMBER
_____	_____	_____

_____ _____ _____
Authorized Signature Title Date

Note: Varian Service will only accept contaminated Turbo or Mechanical Pumps. All other products must be de-contaminated by the customer before Varian Vacuum Products Lexington will assign a Return Authorization (RA) number and authorize the return of the product (refer to the attached Return Authorization Report on the next page).

NOTE: VARIAN VACUUM PRODUCTS LEXINGTON CANNOT ACCEPT ANY BIOLOGICAL HAZARDS, RADIOACTIVE MATERIAL, ORGANIC METALS, OR MERCURY AT ITS FACILITY.

rev. 6/14/94

varian/vacuum products/121 hartwell avenue/lexington/massachusetts 02173/(617) 861-7200
fax number (617) 860-5405

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VPD SERVICE OPERATION

RETURNED MATERIAL REPORT

THIS REPORT MUST ACCOMPANY all products returned for repair, replacement, or warranty evaluation. Full information regarding reasons for return of the product will expedite repair or adjustment. Please fill in all blanks below and furnish any other information which will help identify the nature and cause of failure.

REASON FOR RETURN (check appropriate box)

- ☐ PAID REPAIR
- ☐ ADVANCE EXCHANGE
- ☐ SHIPPING ERROR
- ☐ CREDIT
- ☐ WARRANTY EVALUATION
- ☐ LOANER RETURN
- ☐ SHIPPING DAMAGE

PRODUCT INFORMATION (use separate forms if more than one model no.)

Varian Model No. _____ Serial No. _____ Quantity _____

PART DESCRIPTION _____

PURCHASE INFORMATION (if product is being returned to warranty evaluation, show your original purchase order number and date purchased)

Varian Sales Order No. (if available) _____ MACHINE # _____

Original Purchase Order No. _____ Purchase Order Date _____

COMPANY NAME _____ CONTACT _____

ADDRESS _____

CITY/STATE/ZIP _____ TELEPHONE _____

FAILURE REPORT (describe in detail suspected cause or nature or malfunction)

_____

_____

_____

_____

_____

_____

RETURNED PRODUCTS

All products returned to Varian/VPD Service Operation for Warranty Evaluation must be sent PREPAID and Customer must comply with the WARRANTY REPLACEMENT AND ADJUSTMENT provision set forth in the warranty.

Ship directly to:

☐ VARIAN ASSOCIATES
VACUUM PRODUCTS SERVICE CENTER
121 HARTWELL AVENUE
LEXINGTON, MA 02173

ALL PRODUCTS SOLD BY VARIAN AND RETURNED BY CUSTOMER ARE SUBJECT TO VARIAN ASSOCIATES STANDARD TERMS AND CONDITIONS OF SALE, INCLUDING, BUT NOT LIMITED TO, THE WARRANTY AND DAMAGES AND LIABILITY PROVISIONS SET FORTH IN THE WARRANTY.

MP MASTER
MA25578